

FTD-TT65-1020

AD625149
TT66-60010

TRANSLATION

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AVERAGE DISTILLATE FUELS

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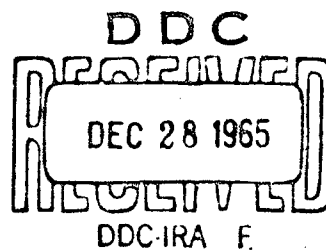


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CHARACTERISTICS OF MICROCONTAMINATIONS IN AVERAGE DISTILLATE FUELS

Ya. B. Chertkov, V. N. Zrelov, et al.

For modern aviation gas turbine engines, equipped with fuel system of considerable delivery with precision pairs of great accuracy (with gaps, measuring 8 - 12 microns) are needed higher purity fuels.

We speak here not only about these mechanical admixtures, the absence of which is controlled according to GOST (State Standard); but also about the micro admixtures, which are not seen by the non-equipped eye.

Some investigators [1] assume, that for satisfactory operation of the fuel system of turbojet engines the amount of

contamination in the fuel, for example Jp-3 should constitute less than 2.65 mg/l with particle dimensions of less than 10 microns and not more than 0.53 mg/l with particle dimensions of 10-80 microns. They have established, that actually fuel, going into the aircraft, contains 3.9mg/l of contaminations with particles of 10 microns and 3.4, g/l with particles of 10-80 microns. On this basis the authors come to a conclusion, that at present time it is impossible to obtain fuel of required purity. In this case, apparently, are not taken into attention contaminations, accumulate in the fuel when it passes through the fuel system of the aircraft.

In 1960 at the 13-th International Conference on Transport Aviation, to assure reliable exploitation of civilian aircraft was adopted a more rigid norm of microcontaminations in the fuel (of not more than 1 mg/l) [2].

At present time are being carried out considerable operations on the creation of fine purification filters of greater passability to separate from the fuel contaminations and water[3].

For jet fuels should be created filters, which can remove completely particles with a dimension of more than 5 microns and could considerably reduce the content of particles with dimension of less than 5 microns [4].

New requirements, pertaining to the purity of jet fuels can be satisfied only at thoroughly studying the composition of microcontaminations and the conditions of their formation in the fuel. Ideas that microcontaminations appear to be mechanical admixtures, which have fallen into the fuel from without and not formed as result of certain conversions, apparently are inaccurate. The of accumulating microcontaminations in fuels is dynamic, i.e. the composition and dimension of contamination particles change continuously.

Studying the nature and rules of formation of contamination microparticles allows to obtain no less effective and accessible media of combatting this negative phenomenon, better than filters with high filtration thinnes, the creation of which encounters considerable difficulties.

Furthermore, since the process is dynamic, and complete insulation of the fuel from contaminated sources (metal of capacities, pipe lines, apparatus, air dust) appears to be impossible, and it may prove, that the best filter without the use of other effective measures does not assure the required degree of fuel cleanliness (particle dimensions of more than 8-12 microns).

About the complexity of the process of forming contaminating solid particles can be judged by data obtained by Walker and

Stanton [5]. These authors with the aid of an electron microscope observed the changes in dimensions of solid particles in fuels of various origin, close by composition to Diesel fuel. In Table 1 are given results of investigating contamination changes of Diesel fuels during storage.

Table 1

| Пробы (1) | Продолжительность хранения, недели (2) | Температура топлива при хранении, °C (3) | Количество частиц микрозагрязнений по размерам в 1 мл топлива, шт. (4) | | | |
|-----------|--|--|--|-----------|----------|----------|
| | | | 0,1-1 мк | 1-5 мк | 5-20 мк | 20-50 мк |
| 1 | 3 10 | 18 | 150 300 | 0 100 | 0 5 | 0 0 |
| 2 | 3 10 | 18 | 200 100 | 0 40 | 0 4 | 0 0 |
| 3 | 6 11 | 18 | 200 150 | 0 20 | 0 3 | 0 0 |
| 4 | 8 14 | 18 | 300 0 | 30 150 | 1 4 | 0 0 |
| 5 | 9 14 | 18 | 0 0 | 50 250 | 50 40 | 1 1 |
| 6 | 9 4 | 38 | 150 200 | 0 50 | 0 2 | 0 0 |

1. Sample
2. Length of storing weeks
3. Temper of fuel during storage °C.
4. Quality of microcontamination particles by dimensions in 1 ml of fuel, units.

Table 2

| Место (1) отбора проб | Частицы микрозагрязнений по размерам в 1 мл топлива, шт. (2) | | | | | | | |
|--|--|--------|------|-------|-------|-------|-------|-------|
| | 1 мк | 3 мк | 5 мк | 10 мк | 15 мк | 20 мк | 30 мк | 40 мк |
| (3) Железнодорожная цистерна | 18 600 | 11 000 | 5050 | 1465 | 250 | 250 | 107 | 72 |
| (4) После фильтра (25 мк) | 5 150 | 1 280 | 536 | 285 | 107 | 35 | 72 | — |
| (5) То же (20 мк) | 2 96 | 1 218 | 930 | 360 | 178 | 72 | 72 | 36 |
| (6) (7 мк) | 1 250 | 750 | 500 | 321 | 178 | 36 | 72 | — |

1. Place of sampling
2. Microcontamination particles by dimensions in 1 ml of fuel, units.
3. Railroad cys tern
4. After filtering (25 microns)
5. ditto (20 micr)
6. ditto 7 micr.

Observations were made over entirely pure fuel, stored in a closed glass vessel. Contamination of the fuel from without on account of metal corrosion and dustiness was eliminated. In ratio to an increase in storage duration at room temperature was observed a change in quality and dimensions of contamination particles. It was clear that the formation of large particles in the fuel takes its origin from particles with dimensions of 0.1 - 1 micron, characteristic for colloidal system.

An increase in fuel temperature leads to the origination of a greater amount of fine particles, which appear to be the original ones for subsequent enlargement and formation of contamination particles of larger dimension.

We have investigated microcontamination in fuel TS-1.

Fuel samples, taken at individual sections, at the time of their passing to the engine fuel system were centrifuged on a supercentrifuge with 3,000 rpm. This enabled as if to separate the fuel concentrate with microcontaminations. In the remanent fuel was contained only a small part of admixtures with particles of less than 1-3 microns. From concentrate the fuel was distilled in vacuum. To separate traces of fuel the residue was washed several times with isopentane and dried to constant weight at room temperature. In this way was obtained the weight of air-dry contaminations. These contaminations were then dried to

constant weight at 105° C. The difference in weight constituted the so called "structural moisture", which appears to be a component part of contaminations. The absolutely dry residue was subjected to elementary analysis for the content of carbon, hydrogen, sulfur and nitrogen. The ashes obtained by combustion of contaminations at 550°C, were investigated on the ISP-28 spectrometer.

The composition of the ashes was quantitatively analyzed for 24 elements. By the difference between the sum of spectrometrically determined elements, carbon, hydrogen, sulfur, nitrogen, and the general weight of absolutely dry microcontaminations was establish the oxygen content.

In Table 2 are given the characteristics of large microcontamination particles in TS-1 fuel.

In the fuel a R/R cystem was detected a greater quantity of particles with a dimension of 1 - 40 microns. The smaller the particles, the greater is their quality. Especially many particles have a dimension of less than 1 micron.

In Table 3 is given the component composition of microcontaminations, detected in TS-1 fuel.

As is evident from the data in Table 3, the ash constitutes about 60- 70%, and in residue more than 80%. The organic part constitutes approximately 20-40%. In all contaminations without

exception was contained "structural" moisture in amount of 6-17% for the entire air dry contaminations.

In this way, regardless of the quantity and coarseness of the microcontamination particles, they consisted in all cases of three components: compounds with ash elements, organic part and moisture.

The elementary composition of absolutely dry microcontaminations of TS-1 fuel is shown in Table 4.

In absolutely dry contaminations the oxygen constituted 18-53%. It is distributed between the organic part (oxygen containing compounds and oxidation packing products) and inorganic part (oxides of ashy elements).

The organic part contains sulfur and nitrogen. The sulfur is distributed between organic and inorganic parts. Nitrogen is included in the composition of organic packing products only.

Contaminations contain a considerable quantity of iron. Even after the paper filter with 7 micron openings, when little contamination remains in the fuel, the fraction of iron in their composition is considerable (13.7%). Hence it is evident that iron is situated in the composition not only of large but also of very small particles, which can pass through the filter and find themselves in the fuel in suspended state. In second place the amount after iron stands silicon, which possesses the same

properties, as iron, to remain in the fuel in known forms in suspended state.

Table 3

| (1) Место отбора проб | (2) Воздушно-сухие загрязнения, g/m | (3) «Структурная» влага в воздушно-сухих загрязнениях, % | (4) Зола абсолютно сухих загрязнений, % | |
|------------------------------|--|---|--|---|
| (5) Железнодорожная цистерна | 1,78 | 16,8 | 57,15 | 1. Sampling place |
| (6) То же (отстой) | 115 | 6,2 | 81,9 | 2. Air-dry contaminations g/m |
| (7) Емкость | 1,04 | 6,9 | 67,8 | 3. Structural humidity from air dry contaminat, % |
| (8) " (отстой) | 2,2 | 7,7 | 84,1 | 4. Ash of absolutely dry contaminations |
| После фильтра | | | | 5. R/R cystem |
| (9) (7 мк) | 0,5 | 15,7 | 57,5 | 6. ditto residue |
| | | | | 7. Capacity |
| | | | | 8. " (residue) after filter |
| | | | | 9. (7 mic) |

To completely eliminate the organic "ash" part or water, constituting the microcontamination of fuels, is impossible even with thin filtration.

It was of interest to establish the composition of contaminations retained from the fuel on the filters. In Table 5 is given the characteristic of microcontaminations of TS-1 fuel detained by certain filters, established sequentially during the decanting of R/R cystem.

On the filter with large openings (40 microns) is held back the thing which was being referred to mechanical admixtures. These contaminations are characterized by high ash content,

very great content of iron and silicon. In their composition we also find "structural" moisture and organic part.

In cloth and paper filters the amount of detained microcontaminations is considerable. Their composition by the content of organic part (60-80%) differs from the composition of contaminations, detained on the 40-micron metal sieve.

In the composition of the ash part of microcontaminations, detained on cloth and paper filters, in first place remains iron, then silicon and others, although their absolute quantity is much smaller than in the ashy part of the contaminations, detained on the metal net.

It is important to underline the fact, that microcontaminations with greater content of organic part, are extracted by cloth and paper filters from standard fuel, which is not subjected to heating, filtered at a temperature of surrounding medium.

In the composition of all air-dry contaminations was contained "structural" water, the amount of which can be most variant depending upon its presence in the fuel (in dissolved or suspended state).

Table 4

| Место отбора проб | O | C | H | S | N | Fe | Si | Ca | Mg | Na | Al | Cu | Zn | Mn | Cr |
|------------------------------|-------|-------|-------|------|-------|------|------|------|------|------|------|------|------|------|------|
| (1) | | | | | | | | | | | | | | | |
| Железнодорожная цистерна (2) | 55,54 | 18,89 | 10,78 | 0,15 | 0,32 | 21,8 | 4,57 | 1,89 | 0,97 | 0,59 | 0,84 | 0,28 | 0,2 | 0,13 | 0,07 |
| То же (отстой) (3) | 53,38 | 8,63 | 3,14 | 0,15 | Следы | 33,0 | 1,12 | 0,01 | 0,25 | — | 0,08 | 0,22 | — | 0,1 | — |
| Емкость (4) | 28,02 | 12,92 | 7,52 | 0,1 | 0,2 | 34 | 6,13 | 2,86 | 1,26 | 0,73 | 0,82 | 0,02 | 1,34 | 0,27 | 0,13 |
| » (отстой) (5) | 18,12 | 12,92 | 7,52 | 0,1 | 0,37 | 45,4 | 12,2 | 2,35 | 1,22 | 0,74 | 0,84 | 0,03 | 1,7 | 0,18 | 0,01 |
| После фильтра (7 мк) (6) | — | — | — | — | — | 13,7 | 0,42 | 3,2 | 2,3 | 0,32 | 1,5 | 0,44 | 5,4 | 0,36 | 2,1 |

1- Sampling place 2- R/R cystem 3- ditto (residue) 4- Capacity
5- " (residue) 6- after fileter (7 micr)

Table 5

| Средний размер пор фильтра, мк | Задержано на фильтре воздуха по сухих затратах, л/с/м | 3 «Трунгуран» влаги воздуха влия, % | 4 Зона абсолютно сухих загрязне ния, % | 5 Зольные элементы абсолютно сухих загрязнений, % | | | | | | | | | | |
|-----------------------------------|--|--|---|--|------|------|-------|------|------|-------------|-------|------|------|-------------|
| | | | | Fe | Si | Ca | Mg | Na | Al | Sn | Cu | Zn | Mn | Cr |
| 40 (сетка) | 0,17 | 5,7 | 83,9 | 50,02 | 6,05 | 0,1 | 1,02 | 0,59 | 0,61 | 0,47 | 0,58 | 0,40 | 0,43 | Отсутствует |
| 35 (ткань) | 0,44 | 6,7 | 30,2 | 8,0 | 2,53 | 1,1 | 0,051 | 3,95 | 0,58 | Отсутствует | 0,25 | 1,59 | 0,19 | 0,78 |
| 25 (ткань) | 0,6 | 15,21 | 18,46 | 6,71 | 0,87 | 0,16 | 0,05 | 2,05 | 0,06 | 0,026 | 0,024 | 0,29 | 0,03 | 0,003 |
| 7 (бумага) | 0,3 | 6,57 | 12,8 | 1,8 | 1,44 | 0,35 | 0,9 | 0,65 | 0,42 | 0,63 | 0,23 | 0,32 | 0,09 | 0,18 |

1- Mean filter pore dimensions, micr. 2- Stopped in filter of air dry contam. g/m

3- Structural moisture in contaminations, %. 4- Ash of absolutely dry contamin, %.

5- Ash elements of absolutely dry contaminations, %. 6- (net) 7- (tissue)

8- (tissue) 9- (paper)

Conclusions

1. Microcontaminations in fuels are formed as result of physico-chemical reaction of compounds with ashy elements, high-molecular tarry compounds and moisture.

2. Compounds with ashy elements fall into the fuel as result of corrosion of the apparatus and transportation media, wear of friction component mechanisms, carrying in of dust from the air, washing out of certain filler of plastic materials.

3. Formation of much larger contamination particles takes place basically on account of enlargement of small particles, beginning with dimensions, characteristic for high dispersion system.

4. Under the effect of temperature, mixing, of excessive pressure and other factors formation of particles with dimension of 0.1 - 1 microns and their further packing increases sharply.

5. To prevent or limit fuel contamination, in addition to known measures, connected with proper exploitation of fuel economy, is adviseable to make systematic removal of moisture from the fuel, prevention of the formation of high molecular tar particles and penetration into the fuel of compounds with "ashy" elements.

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